

## ALUMINIUM ALLOY STRIP FOR WELDING

### FIELD OF THE INVENTION

- [01] The invention relates to aluminium alloy strips, possibly clad on one or two faces with a brazing alloy and intended for the production of brazed parts, particularly heat exchangers for automobiles or buildings, and more particularly parts assembled by fluxless brazing under a controlled atmosphere.

### STATE OF THE ART

- [02] The most frequently used process for the assembly of automobile heat exchangers is brazing. This is based on the use of a clad strip composed of a so-called "core" alloy coated on one or two faces with a so-called "brazing" alloy, at least for one of the components to be assembled. This so-called "brazing" alloy is characterised by a liquid temperature about 30°C less than the solidus temperature of the core alloy. By applying an appropriate heat treatment, it is possible to melt only the cladding, which then wets the surfaces in contact allowing good assembly after the assembly has cooled.
- [03] There are three different brazing techniques presently available:
- [04] The most widespread is brazing under a controlled nitrogen atmosphere, after coating parts to be assembled with a non-corrosive "flux", the most frequently used being the Nocolok® flux. This product, designed to dissolve the surface oxide layer on aluminium and consequently to increase the wettability of the surfaces, is of the potassium fluoroaluminate type. A number of problems arise when it is used. Obviously, the product has an intrinsic cost; its deposition requires special installations that frequently prevent complete automation of exchanger production lines; finally an effluent treatment must be arranged.
- [05] Another older technique but one still used particularly in North America is vacuum brazing. This process makes it necessary to use cladding that contains magnesium; this element is segregated on the surface and vaporises in the vacuum, capturing residual traces of oxygen. It thus avoids the oxide layer, initially broken by differential expansion,

from reforming. No flux is necessary, but vacuum-creating installations are very complicated and associated maintenance costs are very high. For these economic reasons, existing lines are progressively being abandoned and replaced by Nocolok® lines.

- [06] Finally, a third process used more marginally, consists of depositing a nickel layer instead of the flux. Brazing is then done under nitrogen. The energy released during the brazing cycle by the creation of Al-Ni phases on the cladding surface is sufficient to break the oxide layer.
- [07] The main problem consists of performing the brazing operation on existing Nocolok® lines, since these are the most widespread and the most economic, without the use of flux or any other complex surface preparation and without causing degradation of the final properties of exchangers that will be assembled using this technique.
- [08] The solution that has been developed most widely in this field is an adaptation of the nickel deposition brazing process. Although increasingly simplified deposition techniques have been found and used, for example as described in patent application WO 02/07928 (Corus), they never provide more than a partial solution to the problem. The manufacturer of exchangers, or of aluminium strips if the operation is carried out by this manufacturer, must always add on specific installations for surface preparation before brazing and must continue to manage effluents, this time generated by nickel plating baths. Furthermore, although progress has been made in terms of resistance to corrosion as mentioned in patent application WO 02/060639 (Corus), the indicated performances do not always reach the performances claimed for Nocolok® brazed products (for example see patent application WO 02/40729 by Pechiney Rhenalu).
- [09] Other solutions are related to adaptation of the cladding alloy and/or atmospheric conditions in brazing furnaces, as for example in US patent 3 811 177 (VAW) that mentions the addition of the Bi, Sr, Ba or Sb elements into brazing alloys to modify its surface tension. The effect of bismuth on the surface tension is also mentioned in patent EP 0004096 (Ford). More recently, the advantage of adding sodium, possibly accompanied by potassium or bismuth, is mentioned in application WO 01/98019 by Kaiser Aluminium. Finally in EP 1306207 (Sky Aluminium), the brazing that contains

Mg and Bi is covered with a thin layer formed of an aluminium alloy that will remain solid when it begins to melt; it will only break later during the brazing cycle, releasing liquid cladding that then wets its upper surface. Oxidation of the liquid brazing alloy is avoided by working under an atmosphere for a short period. The oxide present on the thin layer is broken when it is surrounded by liquid.

#### **PURPOSE AND OBJECTIVE OF THE INVENTION**

- [10] The purpose of the invention is to enable production by fluxless brazing of parts made of aluminium alloy under good economic conditions, and particularly using the same equipment as is used for brazing with flux under a controlled atmosphere.
- [11] The purpose of the invention is an aluminium alloy strip or sheet containing 0.01 to 0.5% of yttrium and/or 0.05 to 0.5% of bismuth, coated on at least one face with a brazing alloy. The coating may be a layer clad by co-rolling, for example an aluminium alloy containing 4 to 15% of silicon. It may also be a layer comprising particles of a brazing alloy, particularly particles of Al-Si alloy, possibly coated in a resin.
- [12] Another purpose of the invention is a brazed part, particularly a heat exchanger made using an aluminium alloy strip or sheet containing 0.01 to 0.5% of yttrium and/or 0.05 to 0.5% of bismuth.

#### **DESCRIPTION OF THE FIGURES**

- [13] Figures 1a and 1b show a top and side view respectively of V test pieces used in the examples to evaluate the brazability.
- [14] Figure 2 shows the definition of the width of the brazed joint used in the brazability test described in the examples.

#### **DESCRIPTION OF THE INVENTION**

- [15] Unlike the techniques mentioned above, the invention is designed to modify the composition of the core alloy, such that brazing can take place without any deposition, under standard controlled atmosphere conditions, and that can be achieved without modifying the brazing installations used at equipment manufacturers.

- [16] Surprisingly, the addition of some elements in the core, such as yttrium at a content of 0.05% or bismuth at a content of about 0.15%, can result in a very satisfactory quality of brazed joints for fluxless brazing under nitrogen.
- [17] The method is applicable to all types of aluminium alloys containing at least 80% by weight of aluminium, and particularly alloys for which the composition satisfies the following conditions (% by weight) before the addition of elements specifically intended to enable fluxless brazing:
- Si < 1.0; Fe < 1.0; Cu < 1.0; Mn < 2.0; Mg < 3.0; Zn < 6.0; Ti < 0.3; Zr < 0.3; Cr < 0.3; Hf < 0.6; V < 0.3; Ni < 2.0; Co < 2.0; In < 0.3; other elements < 0.05 each and 0.15 total; remainder aluminium.
- [18] The sheet or strip may be clad by co-rolling on one or two faces with a brazing aluminium alloy, usually an alloy containing 4 to 15% of silicon. The brazing alloy may contain other additives such as copper, magnesium or zinc. It may also contain elements designed to modify the surface tension of the alloy, such as Ag, Be, Bi, Ce, La, Pb, Pd, Sb, Y or mischmetal, in other words a mixture of unseparated rare earth metals. In the case in which the brazing alloy is clad on a single face, the other face may be coated by a sacrificial alloy, usually of the Al-Zn type, in a manner commonly known and intended to improve the resistance of the core alloy to corrosion.
- [19] The brazing alloy may also be deposited in the form of particles, particularly Al-Si particles, for example as described in patent EP 0565568 (Alcan International). For brazing under a controlled atmosphere, the brazing alloy particles are usually associated with flux particles, particularly flux based on fluorides such as potassium fluoroaluminate, and a binder such as a polymer resin. One particular advantage of the invention in this case is to avoid the presence of flux in the coating.
- [20] The alloy sheet with the addition of bismuth and/or yttrium may also be used uncoated when it is associated with another sheet coated with a brazing alloy for the production of the brazed part.

## EXAMPLES

### Example 1

- [21] Four plates of core alloys with the following compositions were cast:

ALLOY	SI	FE	CU	MN	MG	TI	Y	BI	CA
M	0.40	0.22	0.63	0.57	0.47	0.08	-	-	-
M + Y	0.39	0.24	0.61	0.57	0.47	0.09	0.06	-	-
M + BI	0.39	0.22	0.62	0.59	0.49	0.09	-	0.15	-
M + CA	0.40	0.22	0.63	0.57	0.47	0.08	-	-	0.05

together with a 4047 cladding alloy plate (Al - 12% Si). Assemblies were made from these plates such that the thickness of the cladding alloy represents 10% of the total thickness. These assemblies were hot rolled and then cold rolled so as to produce 0.3 mm thick clad strips. These strips were then subjected to a restoration treatment for 10 h at 260°C.

- [22] The test piece illustrated in Figure 1 was used to evaluate the brazability of these materials. The "V" is composed of a 0.3 mm thick bare strip made of a 3003 alloy in the H24 temper. A 15-minute degreasing treatment at 250°C was applied to the metal to be brazed. No other surface preparation was used and in particular no flux was deposited. Brazing is done in a double-wall glass furnace in which it is possible to view movements of liquid brazing alloy and the formation of joints during the treatment. The thermal cycle is composed of a temperature rise phase up to 610°C at a rate of approximately 20°C/min, holding for 2 minutes at 610°C, and then lowering at a rate of about 30°C/minute. The complete process is done under continuous nitrogen scavenging, at a rate of 8 l/min.

- [23] The results are marked A to E at the following scale:

Mark	A	B	C	D	E
Joint length formed as a percent of the total length	100%	90%	75%	50%	0%

[24] The results are given in table 1:

Table 1		
Core	Cladding	Brazability
M	4047	E
M + Y	4047	A
M + Bi	4047	A
M + Ca	4047	E

[25] The improvement in the brazability obtained due to the addition of Y or Bi to the core alloy can be seen.

#### Example 2

[26] Two plates with the following compositions were cast in the same way:

Alloy	Si	Fe	Cu	Mn	Mg	Ti	Y
N	0.17	0.18	0.64	1.37	-	0.08	-
N + Y	0.19	0.17	0.67	1.32	-	0.09	0.06

together with a 4045 cladding alloy plate (Al - 10% Si). The transformation procedure and the tests carried out are exactly the same as for example 1.

[27] The results are given in table 2:

Table 2		
Core	Cladding	Brazability
N	4045	E
N + Y	4045	A

[28] It can be seen that the addition of yttrium to alloy N significantly improves the brazability.

## Example 3

- [29] Two plates with the following compositions were cast in the same way:

Alloy	Si	Fe	Cu	Mn	Mg	Ti	Y
P	0.15	0.35	0.1	0.1	0.8	0.125	-
P + Y	0.15	0.35	0.1	0.1	0.8	0.125	0.06

together with a 4045 cladding alloy plate (Al - 10% Si). The transformation procedure and the tests carried out are exactly the same as for example 1.

- [30] The results are given in table 3:

Table 3		
Core	Cladding	Brazability
P	045	E
P + Y	4045	A

- [31] It can be seen that the addition of yttrium to alloy P significantly improves the brazability.